ROBUST SATELLITE TECHNIQUES (RST) FOR MONITORING THERMAL ANOMALIES IN SEISMICALLY ACTIVE AREAS

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1. INTRODUCTION

On the basis of night-time Thermal Infrared (TIR) satellite observations, previous studies (e. g. [1, 2, 3, 4, 5]) have been suggesting for decades a space-time correlation between TIR anomalies and earthquake activity. Among the others, a Robust Satellite data analysis Technique (RST) [6], based on the RAT - Robust AVHRR (Advanced Very High Resolution Radiometer) Techniques - approach [7], was proposed which provides a statistically based definition of "TIR anomalies" and a suitable method for their identification even in very different local (e.g. related to atmosphere and/or surface) and observational (e.g. related to time/season, but also to solar and satellite zenithal angles) conditions. The possible applications of RST to satellite TIR surveys in seismically active regions were already tested in the case of tens of earthquakes [8, 9, 10, 11, 12, 13, 14, 15, 16, 17] occurred in different continents (Europe, Asia America and also Africa). The RST analysis has been always carried out by using a validation/confutation approach, to verify the presence/absence of anomalous space-time TIR transients in the presence/absence of seismic activity.

Between the various genetic models, the increase of green-house gas (such as CO_2, CH_4, etc.) emission rates have been also suggested to explain the appearance of such anomalous TIR signal transients, in some relation with the place and time of earthquake occurrence [5, 12, 17]. In previous works [11, 13, 14,], seismic events occurred in areas characterized by different prevailing degassing activity (i.e. CO_2 or CH_4) have been considered, to explain how an enhanced greenhouse gas emission cannot be excluded among the main causes of TIR anomalies observed close to earthquake occurrence. In fact, this explanation does not conflict with our observations that thermal anomalies related to earthquakes generally respond to morphological lineaments (i.e. tectonic faults), as it is expected for diffusing gases heavier than air as CO_2. Sometimes, such an overlapping is less well-marked, as it is expected for diffusing gases lighter than air as CH_4. The observance by satellite of different shape, extension and space-time persistence of TIR anomalies prior to and after earthquakes lead us to further investigation about the phenomenon origin. The results we obtained stress that the space-time signature of TIR anomalies we observed could actually depend on the density (greater or lower than air) of the main emitted gas.

2. RESULTS OVER AFRICAN CONTINENT

The RST have been applied to the African region to assess its potentialities in very different geographical and climatic conditions [13, 14]. Eight years of Meteosat TIR observations have been analyzed in order to characterize the TIR signal behavior in absence of significant seismic activity at each specific observation time and location. Boumerdes/Thenia (Algeria) earthquake (occurred on 21th May 2003, Mb= 6,8) has been considered as test case for validation purpose, while a relatively unperturbed period (no earthquakes with M_b>4) has been analyzed in the confutation phase. The results of the analysis show that the area of interest is affected by positive time-space persistent TIR anomalies about one month before the main shock. Such anomalies generally overlap the principal tectonic lineaments of the region, sometimes focusing in the vicinity of the earthquake epicenter. As far as the confutation analysis is concerned, the results well highlight that no similar (in terms of relative intensity and space-time persistence) TIR anomalies were detected during seismically unperturbed periods. It is worth to say that Algeria is known as area characterized by an intense CH_4 outgassing activity. On the other side, the diffuse thermal anomalies which we observed next to the main tectonic structures of the Algerian region could be caused by a dominant escaping of a gas lighter than air (i.e. CH_4). The results achieved by applying the RST approach to the Algeria, characterized by strong degassing (mainly CH_4), did not contradict the general gas diffusion models.

Even if it is still not possible to relate (or to exclude) observed anomalous TIR transients definitely to impending earthquakes, this and our previous studies seem to demonstrate: the strong improvement of Signal(S)/Noise(N) ratio achievable moving from polar (i.e. NOAA National Oceanic and Atmospheric Administration) to geostationary satellites (i.e. Meteosat); the further S/N improvement achievable by using TIR sensors which also offer split-window possibilities; the crucial role played by a space/time persistence test to select TIR anomalies candidate to be associated to impending earthquakes; the possibility of identifying and correctly discarding TIR anomalies related to clouds and to image navigation errors; the scarce importance of spatial resolution of observations which encourages the use of passive Micro Wave sensors which are less affected by atmospheric conditions; the abrupt change of degassing regimes of greenhouse gases, as possible cause of observed pre-seismic TIR anomalies.

3. REFERENCES

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